Mechanics of respiration

INTENDED LEARNING OBJECTIVES (ILOs)

By the end of this lecture the student will be able to:

1- Describe the mechanics of normal and forced inspiration.
2- List the muscles involved in normal quit inspiration as well as forced inspiration
3- Describe the mechanics of expiration.
4- List the muscles involve involved in forced expiration.
5- Explain the intra-pleural pressure changes during breathing as well as the intra-alveolar pressure changes.
6- Explain the causes of negative intra-pleural pressure and its significance.

Respiratory cycle is composed of:

1. **Inspiration:** movement of air from atmosphere to alveoli.
2. **Expiration:** movement of air from alveoli to atmosphere.
3. **Expiratory pause**

Inspiratory muscles	Result of contraction	Time of contraction
1) Diaphragm	Descends downwards, increasing vertical diameter of thoracic cavity.	**Every inspiration**, its primary muscle of inspiration.
2)External intercostal muscles	Elevates ribs upwards & outwards, enlarging thorax, in both antero-posterior and lateral diameters.	**Every inspiration** =2ry.Complementary role to diaphragm.
3) Scalenus, sterno cleido-mastoid muscle	Elevates sternum & first two ribs, enlarging upper portion of thoracic cavity.	Only during **forced inspiration**

Respiratory rate 12-16 breath/min

Respiratory muscles

Expiratory muscles	Result of contraction	Time of contraction
1) Abdominal muscles	Increase intra-abdominal pressure, which exerts upwards force on diaphragm to decrease vertical diameter of thorax.	Only during active **(Forced expiration)**
2) Internal intercostal muscles	Flatten thorax by pulling ribs downwards and inwards,decreasing transverse diameter of thorax.	Only during active **(forced) expiration**

IMPORTANT PRESSURES FOR VENTILATION

Atmospheric pressure: The pressure of air surrounding the body = 760 mm Hg. At sea level. It is considered 0 mmHg when other pressures is related to it._

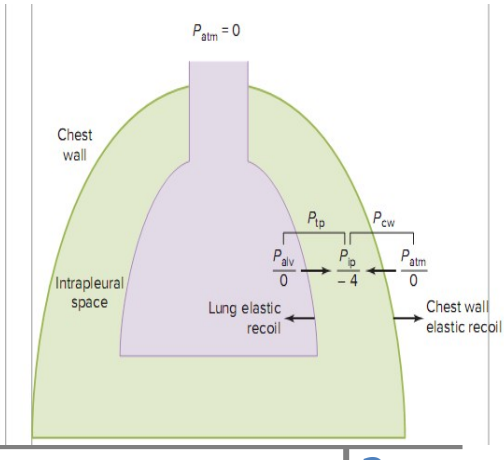
Intra-alveolar pressure: Also known as intrapulmonary Pressure. It is the pressure inside the alveoli.

It equilibrates with the atmospheric pressure because the alveoli are in direct communication with the atmosphere so air will move from the higher pressure to the lower one.

It is less than atmospheric (-1) during inspiration

It is more than atmospheric (+1) during expiration

Intrapleural pressure: Also known as intrathoracic pressure



no direct communication between the intrapleural and atmospheric pressure.

Values:

-4 = beginning of inspiration.
-6 = End of inspiration.
-30 = forced inspiration.
+40 = forced expiration.

Causes of negativity of I.P.P

Due to inward recoil tendency of lungs and outward recoil tendency of thoracic wall.

Recoil tendency of the lung, is due to:

1) Elastic recoil:

- Relaxation volume of the lung = 1 liter.

- Relaxation volume of thoracic wall = 5 liters

- At end of normal expiration both are equal to 2.5 liters Thus the lung tends to recoil inward 2.5 → to 1 liter, and the thoracic wall tends to recoil outwards 2.5 →to 5 liter**.**

2) Surface tension: Of the fluid lining the alveoli**.**

Significance of negativity of I.P.P :

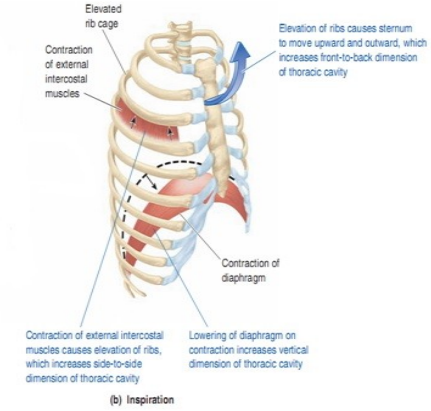
1) Expansion of the lung.
2) Venous return.
3) Lymph flow in the thoracic duct.
4) Deglutition.
5) Pulmonary blood flow**.**

Causes of positivity of IPP:

1)Forced expiration (Physiological).
2)Pleural effusion.
3)Emphysema→ (Pathological).
4) Pneumo ,Pyo, haemo, chylothorax.

Transmural pressure gradient
Pressure across the lung wall (Transpulmonary pressure gradient)

= The pressure inside the lungs - pressure just outside it (pressure in pleural sac)
= intra-alveolar pr --intrapleural pr
= 760- *756 = 4* mm Hg.
Transpulmonary pressure gradient keeps the alveoli open (distending pressure)_



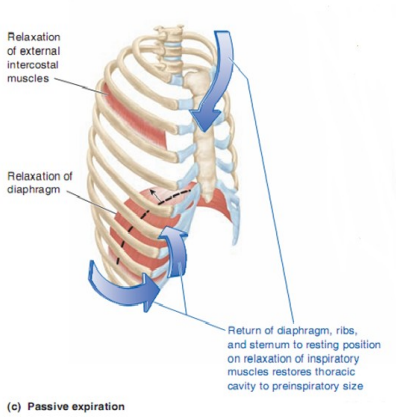
Pressure across thoracic wall (Transthoracic pressure)
= intra-pleural pr – atmospheric pressure
= 756-760 = - 4 mm Hg.
Trans-thoracic pressure pushes inward on thoracic wall (compressing pressure)

Mechanics of normal inspiration

1. Normal quiet breathing is accomplished by contraction of diaphragm and external intercostal muscles.
2. Increases thoracic cavity volume and decrease in intrathoracic pressure.
3. Lung is forced to expand
4. Decreases intra- alveolar pressure
5. Air flows in alveoli according to pressure gradient

Mechanics of forced inspiration

1. Strong contraction of diaphragm and external intercostal muscles
2. Contraction of accessory inspiratory muscles (scalenus and sternocledomastoid)
3. More decrease in intra-alveolar pressure and more air flow will enter the lung.



Mechanics of normal expiration

Quite expiration is a passive process
1. Relaxation of the diaphragm and external intercostal muscles.
2. Chest wall recoil to pre-inspiratory position.
3. Decrease thoracic volume
4. Recoil of the lung and increase the intra-alveolar pressure

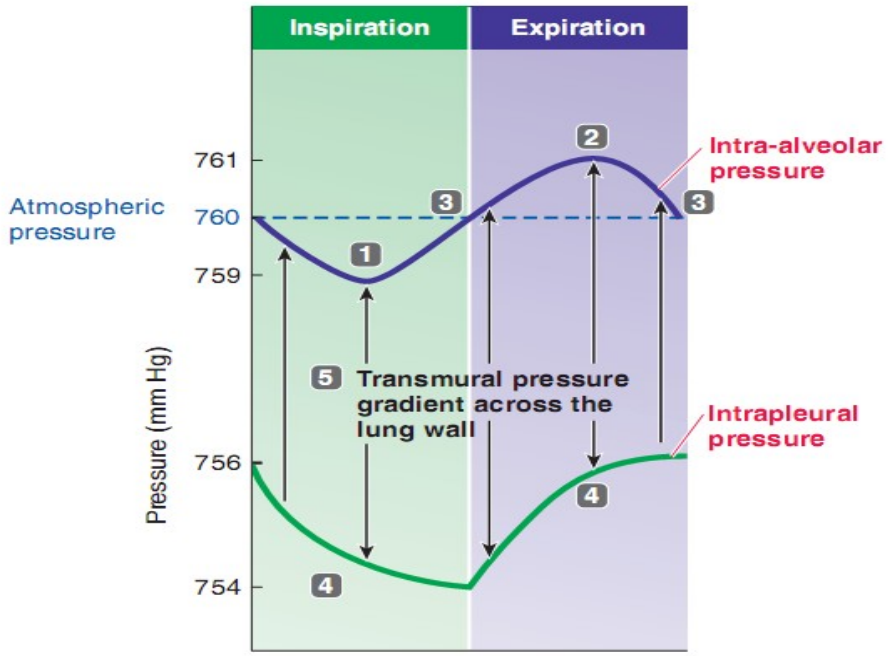
Air leaves the lung down the pressure gradient.

Mechanics of forced expiration

It is an active process

1. Contraction of the expiratory muscles (abdominal and internal intercostal muscles.
2. Further decrease in thoracic dimension with more reduction in lung volume.
3. Increase the intra-alveolar pressure more than in quiet expiration
4. Forcing more air to exit from the lung

Pressures that cause the movement of air in and out of the lungs



SUGGESTED TEXTBOOKS

1. Guyton and Hall textbook of medical physiology, thirteenth edition 2016 by Elsevier chapter 38 , from page 497 to 499
2. Ganong's Review of Medical Physiology, twenty-fifth edition 2016 by McGraw-Hill Education, chapter 34, from page 624 to 628
3. Human Physiology: From Cells to Systems, Ninth edition 2016. by CENGAGE, chapter 13, from page 450 to 456 Lauralee Sherwood